Surface Cleanliness Algorithms

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Why Algorithms?

- A series of equations used to determine an answer to a question.
- Question:

  When a surface is contaminated, what contaminant concentration or loading would pose a serious ingestion hazard?

Why is there a need for Surface MCLs?

- Risk assessments considering airborne exposures alone, fail to include contributing exposure pathways of ingestion and skin absorption, in some cases ingestion can be the primary exposure route.
- Note: MCL – Maximum Contamination Level, the maximum level of allowed contamination, above which, actions are taken to reduce the amount of contamination

Why is there a need for Surface MCLs?

- ACGIH Lead TLV documentation (2001) states “ …the TLV-TWA is intended to maintain worker blood levels below the BEI of 30 ug/dl. Maintaining blood levels at or below this level must also focus on control of exposure to non-airborne sources of lead…”

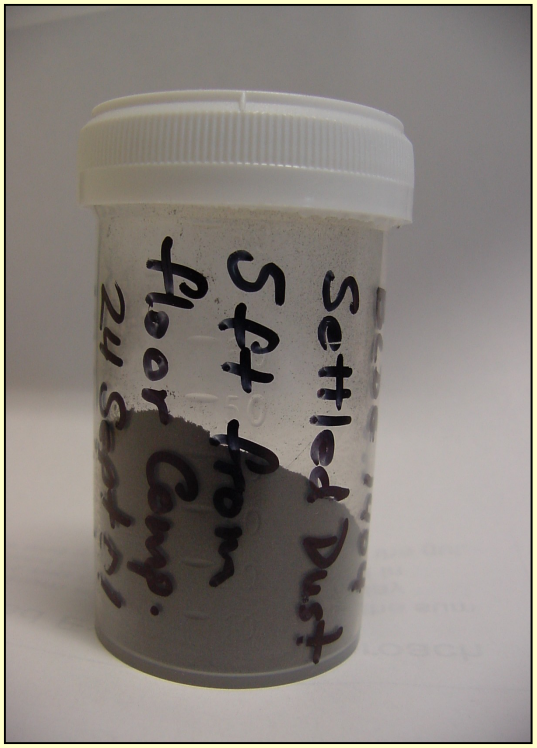
Scarcity of Regulatory Based Surface MCLs

- OSHA states in CPL 2-2.58 that “In determining whether an employer has maintained surfaces of hygiene facilities free from contamination, OSHA recommends the use of HUD’s recommended level for acceptable decontamination of 200 µg/ft^2 for floors…”
- Note: Changed to 100 µg Pb/ft^2

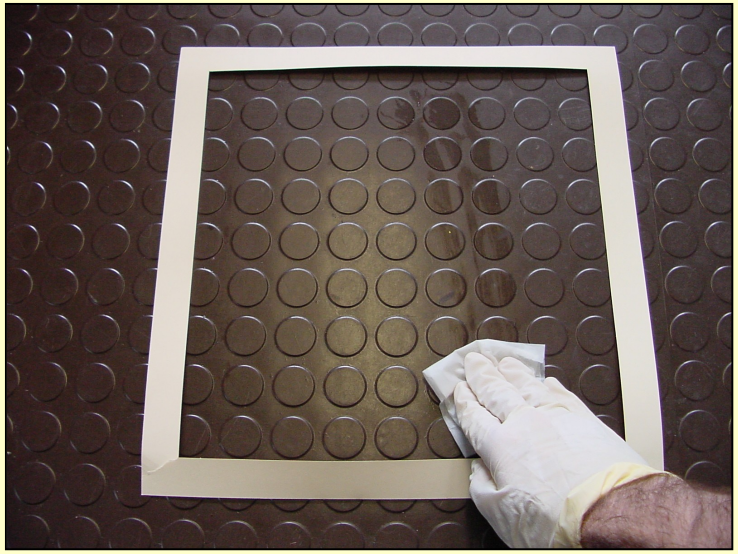
- Others?

Surface Contaminant MCLs

- Surface Concentration MCL



- Surface Loading MCL



Three Steps to an MCL

1. Determine a Maximum Allowed Exposure
2. Calculate the Dermal Dose Rate
3. Determine the Contaminant Weight Fraction (conc.) or Surface Loading. This contaminant value will provide the MAE, and can be used as the MCL.

Maximum Allowed Exposure Approach

- An approach for creating MCLs based on the “maximum allowed exposure” based on a TLV, PEL, STEL or other exposure limits.
- Toxicological data
- Hand to Mouth transfer frequency
- Hand Loading
- Airborne exposure data
- Knowledge of vulnerable subpopulations of workers

Maximum Allowed Exposure Approach

- Choose a logical daily exposure limit based on employee protection and applicability (maximum allowed exposure)
- Consider volume typically inhaled per 8 hour work day by typical employee (10 cubic meters/day)
- Determine the amount of contaminant absorbed via inhalation and ingestion based on size selective sampling results

Case Study

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Maximum Allowed Exposure

The maximum allowed exposure is the product of:

0.01 mg Cd/m^3 X 10 m^3/day multiplied by the percent absorbed in lungs and the percent absorbed in the gut.

Maximum Allowed Exposure

Ex: Assume 100% of contaminant dust is respirable and enters in the lungs, and that 30% of the cadmium entering the lungs is absorbed and that 70% of cadmium is expelled and swallowed with 8% entering the digestive system absorbed (Casarett, 2001).

(0.1 mg Cd/day x 30%) + (0.1 mg Cd/day x 70% x 0.08) = 0.0356 mg Cd per day

Dermal Dose Rate

EPA Proposed Dermal Exposure Risk Assessment Tool

Ds = WF x SA x Q (concentration)

Ds = C x SA x S2H x FS2H (loading)

EPA Proposed Dermal Exposure Risk Assessment Tool (Surface Conc.)

Ds = WF x SA x Q

Ds = dermal the dose rate per day (mg/ day)

WF = Weight fraction (mg/kg)

SA = the surface area of contact (Palms of hands ≈ 180 cm^2)

Q = amount of material on the area of contact

(mg/cm^2)

EPA Proposed Dermal Exposure Risk Assessment Tool (Surface Loading)

$Ds = C \times SA \times S2H \times FS2H$

Where:

Ds = dermal the dose rate per day (mg/ day)

C = Contaminant loading (mg/cm^2)

SA = the surface area of contact (Palms of hands ≈ 180 cm^2)

S2H = number of surface to skin contacts/day

FS2H = fraction transferred surface to skin

Gastrointestinal Absorption

GI = Ds x FH2M x FIA x H2M

Equation is used to determine the mass of contaminant absorbed per day

Where:

GI = amount of contaminant absorbed (mg)

Ds = dermal the dose rate per day (mg/ day)

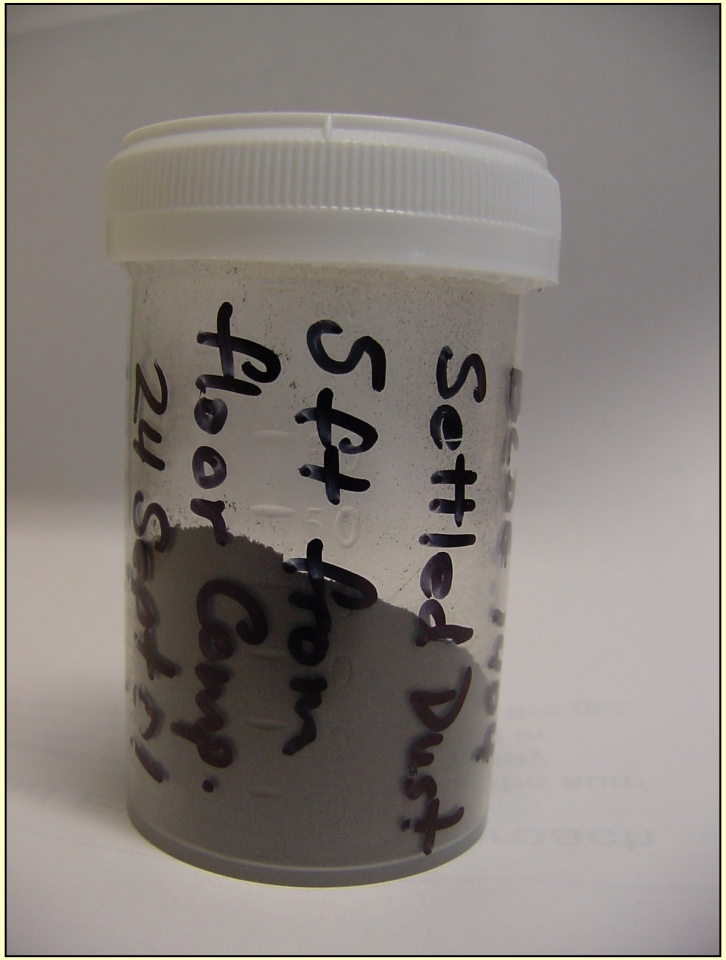
FH2M = fraction moved from hand to mouth

FIA = fraction of ingested contaminant absorbed

H2M = number of contacts/ day

Surface Concentration MCL

- A maximum contamination level based on concentration, generated from sampling a mass of settled dust is useful in areas with bountiful settled dust.



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Surface Concentration MCL

- Solve the EPA and GI equations to arrive at the weight fraction (WF), using the maximum allowable cadmium exposure (0.0356 mg/ day) as GI the amount of contaminant Absorbed per day (mg/day)

- The WF value is the concentration of cadmium in settled dust that will provide the maximum allowed exposure, a handy value which may be used as the MCL.

Surface Concentration MCL

- MAE (GI) = Ds x FH2M x IA x H2M, rearrange to solve for Ds

Ds = MAE (GI) ÷ (FH2M x IA x H2M)

Note = Ds is the amount of contaminant on hands during the day giving the MAE.

Surface Concentration MCL

- Using Case Study Data
- Ds = 0.0356 mg Cd/day ÷ (10% x 8% x 36)
- Ds = 0.1236 mg Cd/day
- Conclusion: You need to have a considerable amount of Cadmium on hands to reach the MAE

Surface Concentration MCL

- Ds = WF x SA x Q, rearrange to solve for WF

  WF = Ds ÷ (SA x Q)

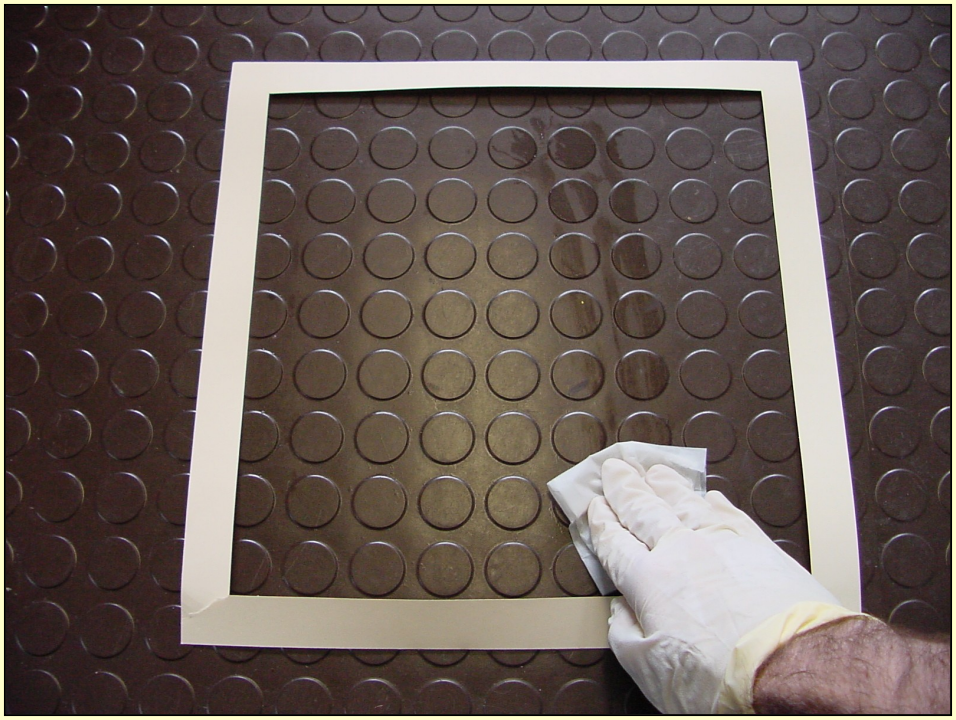
  Note: WF is the weight fraction, the concentration of contaminant that will provide the MAE.

Surface Concentration MCL

- Using Case Study Data
- WF = 0.1236 mg Cd/day ÷ (180 cm^2 x 1 mg/cm^2)
- WF = 0.00069 = 690 mg/kg
- Conclusion: 690 mg Cd/kg is the concentration of Cadmium providing the MAE. The WF may be used as an MCL.

Surface Loading MCL

- A maximum contamination level based on surface loading, generated by sampling a surface area's contaminant load by wiping a determined area, esp. useful in areas with limited mass of settled dust.



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Surface Loading MCL

- Solve the EPA and GI equations to arrive at the contaminant loading (C), using the maximum allowable cadmium exposure (0.0356 mg/day) as GI the amount of Contaminant Absorbed per day (mg/day)

- The C value is the contaminant loading on a surface that will provide the maximum allowed exposure, a handy value which may be used as the MCL.

Surface Loading MCL

- MAE (GI) = Ds x FH2M x IA x H2M, rearrange to solve for Ds

Ds = MAE (GI) ÷ (FH2M x IA x H2M)

Note = Ds is the amount of contaminant on hands during the day giving the MAE.

Surface Loading MCL

- Using Case Study Data
- Ds = 0.0356 mg Cd/day ÷ (10% x 8% x 36)
- Ds = 0.1236 mg Cd/day
- Conclusion: You need to have a considerable amount of Cadmium on hands to reach the MAE

EPA Proposed Dermal Exposure Risk Assessment Tool (Surface Loading)

$Ds = C \times SA \times S2H \times FS2H$

Where:

Ds = dermal the dose rate per day (mg/ day)

C = Contaminant loading (mg/cm^2)

SA = the surface area of contact (Palms of hands ≈ 180 cm^2)

S2H = number of surface to skin contacts/day

FS2H = fraction transferred surface to skin

Surface Loading MCL

- Ds = C x SA x S2H x FS2H, rearrange to solve for C

$$C = Ds \div (SA \times S2H \times FS2H)$$

Note: C is the contaminant loading, the loading of contaminant that will provide the MAE.

Surface Loading MCL

- Using Case Study Data
- C = 0.1236 mg Cd/day ÷ (180 cm^2 x 36 x 50%)
- C = 0.000038 mg Cd/cm^2 = 0.0038 mg Cd/100cm^2
- C = 3.8 µg Cd/100cm^2
- Conclusion: 3.8 µg/100cm^2 is the cadmium loading providing the MAE. The C may be used as an MCL.

MCL Conclusions

- Maximum Allowable Exposure is the total contaminant absorption, based on the sum of all exposures
- The EPA risk assessment tool and GI absorption, are dependent on the factor H2M (number of contacts/ day), which should be based on the most sensitive worker subpopulation

MCL Conclusions

- Surface contaminant MCLs based on exposure limits may be determined for areas without regulatory limits in place.
- These MCLs are based on estimated exposure for certain subpopulations, they may not be applicable for every subpopulation, i.e. pregnant employees

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